Physics 129: Problem Set #9

Because the GREs are next weekend, this HW is due

Monday Nov 12 at 5PM

Homework Box available on 2^{nd} Floor LeConte breezeway

REMEMBER: Midterm # 2 is on Wed Nov 14.

1. The B^- meson decays when the b quark in that meson emits a W^-. The W^- can then turn into any of the lepton families or into the first two quark families.

   (a) Draw Feynman diagrams for these decays. In each case, explain what CKM matrix element belongs at each vertex.

   (b) Estimate the branching ratio for $B^- \to X e^- \overline{\nu_e}$ (Don't forget to include a color factor for the quarks the same way you do when calculating R in e^+e^- annihilation)

   (c) Using the B^- lifetime from the Particle Data Book and the diagrams you drew in part (a), estimate the value of CKM matrix element V_{tb}. Note: to do this problem, you must use the fact that the CKM matrix is unitary. You may assume that the formula for muon decay can be used for the B^- decays if you replace the μ mass with the B mass and include the appropriate CKM factors (as in Perkins 7.43).

2. Consider the leptonic decay $B^+ \to \ell^+ \nu_\ell$. This is a very rare decay that has not yet been observed.

   (a) Explain in words why this decay is so rare.

   (b) Using the information on page 212 of Perkins, calculate the relative rates for the B^+ to decay to the 3 lepton species e, μ and τ.

   (c) If you make the assumption that the matrix element for this decay is identical to that for $K^+ \to \mu\nu_\mu$ aside from the factors described on page 212, what would you predict for the partial width $\Gamma(B \to \mu\nu_\mu)$? (Use the Particle Data Book to get the relevant information for the K^+.)

(d) Using the results from part (c) and the total B^+ decay width from the Particle Data Book, calculate the branching ratio for $B^+ \to \tau^+ \nu_\tau$

(e) The PEP-II e^+e^- collider at SLAC has reached its design luminosity of 3×10^{33} cm^{-2}sec^{-1}. The cross section for the process $e^+e^- \to B\overline{B}$ at this energy is about 1 nbarn. How many years will PEP-II need to run before 10 events in the channel $B^+ \to \tau^+ \nu$ are produced? Assume that the accelerator runs for 10^7 sec per year.

3. Perkins 7.2 This problem will tell you alot about how a neutrino beam is made at an accelerator laboratory.